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ABSTRACT

A discussion of the nature and process of phonological changes taking places in languages looks specifically at the merging of allophones and the reorganization of phonemes in response to pressures within the phonological system. The hypotheses of economy and reorganization are used to analyze the process of change within a phonological system. Two languages are examined: Uzbek, a Turkic language with a vocalic system derived from classical Chagatay, and a variety of English spoken in Rhode Island. The analysis is illustrated with a three-dimensional model. Both the hypotheses and the space theoretical model are seen as useful in tracing the courses of already-established sound changes. (MSE)

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Allophonic Merger and Phonemic Reorganization in Chagatay/Uzbek and Rhode Islandese

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0. Introduction.

While the larger part of the literature of historical linguistics since the 19th Century has been in the establishment of relationships between languages and in the reconstruction of proto-languages, only in the last few decades, particularly in the work of such researchers as Andre Martinet, William Moulton, William Labov and several others, has there been much progress towards determining the nature of the changes themselves.

Knowledge of a mother-daughter pair of languages may be sufficient to obtain a list of *descriptive* diachronic rules of the type mother /e/ > daughter /i/, but may give us little or no information about the *process* through which the change took place. The first of the two case studies I will present today will be of a speculative nature, using data from such a mother/daughter pair; allophonic variation in the daughter language is considered in an attempt to determine the most probable route the phonological system of the language took in its gradual loss of several vocalic distinctions.

A more detailed and less speculative source of data regarding the routes followed by individual segments of a system is a group of people speaking a continuum of related dialects or idiolects. Labov, Yeager and Steiner (1972) and the second case study that I will present today are examples of this approach.

Before presenting these studies, I will spend a few moments describing the model of phonological space that I have used in various forms since 1977, and present two working hypotheses concerning the circumstances under which a *sound* change can or will precipitate changes in the *phonological* system.

In most generative work on sound change, it is asserted, or at least implied, that most or all sound changes can be described by means of diachronic rules involving changes in the value(s) of a binary feature or features. While such "binary" rules can be accurate in a descriptive sense, few researchers now believe that they represent in any real way the processes or mechanisms of sound change. In Breen (1977) and in more recent work, I have been more interested in the *routes* taken by vowels in their migrations rather than just the results of the migrations, so I reject the strict binary approach in favor of a framework that includes the use of multiple or scalar values, at least for the feature of tongue height, following Moulton (1983, and earlier work).

1. Terminology and the Model.

In this model, each phoneme is considered to be a set of allophones; the *nucleus* of a phoneme is its norm, i.e., the allophone associated with that phoneme which occurs in the least restricted environments. The range of the phoneme about this nucleus is referred to as its *field*.

Any instability in a phonological system is called a *pressure*. Pressures are of two types: *Functional pressures* are those caused by restrictions in articulatory space; *structural pressures* are those caused by 'nonparallelisms' in the organization

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of a phonological system. There are, in turn, two types of functional pressure: *gap* pressure, which occurs when there is felt to be an excess of distance between the nuclei of two neighboring phonemes, and *crowding* pressure, which occurs when the nuclei of two neighboring phonemes are felt to be too close.

There are, of course, many possible reactions to pressure, but for the purposes of this talk, I will mention only three: *merger*, *stretching*, and *migration*.

A *merger* has occurred when two once-distinct phonemes are no longer distinguished from one another in any environment. This is most likely when the nuclei of the two phonemes are initially quite close, their fields overlapping, and, most importantly, when the functional yield of their opposition is low. Another type of merger, generally less immediately catastrophic to the system than a complete phonemic merger, results from the confusion of similar allophones belonging to different phonemes. If the confusion is complete, one of the two overlapping phonemes will generally lose that allophone to the other. This is what I mean by allophonic merger, and there is a lot of it going on in Rhode Islandese, which I'll be getting to shortly.

In *stretching*, the field of a phoneme expands in one or more directions, but its nucleus remains in the same location, while in *migration*, the nucleus does move in some direction to relieve pressure. In a theory assuming lexical diffusion as the means of sound change, stretching would be assumed to precede migration, the migration presumably proceeding in the direction of the spread.

Figure 1 shows some examples of this terminology. In these diagrams, each phoneme is represented by a dot surrounded by a closed line, representing, respectively, the phoneme's nucleus and the borders or limits of its field. Arrows designate the direction of stretching or migration. Each phoneme is labeled by means of an upper case letter, serving only to distinguish it from other phonemes and not to represent any particular phonetic characteristic.

Having established a terminology to describe some of the phenomena of sound change, my next task is to develop guidelines for the development of geometrical models for a variety of vocalic systems.

For the diagrams in Section 3 on Chagatay/Uzbek, I use a three-dimensional model developed in Breen (1977) to represent phonological space, the first two to represent tongue height and location (these are probably universal for vowel systems) and the third being lip rounding, which is nonpredictable in Turkic languages. For my discussion of Rhode Islandese, I use a system of two-dimensional matrices, as allophonic variation is crucial to some of my arguments, and these are more difficult to illustrate clearly in the geometric model.

2. Two Hypotheses: Economy and Reorganization

While the migration of an allophone to a new location, the disappearance of an allophone from a phoneme or its reassignment to a different phoneme all fall under the general rubric of sound change, the complete loss of a phoneme or the complete merger of two neighboring phonemes is of a different nature, involving not just the relative location of one or more sounds, but the organization of an entire system.

Informally, a phonemic system will tend to reorganize when this will simplify or economize the system. If through the loss or migration of one or more allophones two neighboring phonemes find themselves in complementary distribution, it would clearly be more economical for the two phonemes to merge. My claim is that they will, provided they are close enough and there are no intervening allophones from other phonemes. In the case of neighboring phonemes

that contrast in only one environment, what will happen depends, of course, on the productivity of the contrast. If one or the other contrasting allophones is of relatively low frequency, or if the number of minimal pairs is low, the chances for merger of the two allophones, and for the subsequent merger of the two phonemes, are good.

This discussion of reorganization and economy can be summarized in two hypotheses, given on your handout as (1) and (2):

(1) *Economy of Organization Hypothesis*

A phonemic system will organize so as to require the smallest number of phonemes necessary to represent the system.

(2) *Reorganization Hypothesis*

Two phonemes that have been put into complementary distribution due to allophonic loss, merger or migration will themselves merge iff: (1) they are adjacent in phonological space and (2) there are no intervening allophones belonging to other phonemes.

3. Chagatay and Uzbek

Proto-Turkic is generally assumed to have had a system of eight vowel phonemes, shown here in Figure 2 with their approximate locations. The structural interrelationships in this system are quite strong, due partly to the presence of vowel harmony as an active mechanism in the morpho-phonemics of the grammar (Menges, 1968). Note, however, that the phoneme /a/ is considerably lower than each of the other non-high vowels in the pattern; this pronounced skewness of /a/ has the potential of introducing an instability into the system. A gap pressure may be felt between /a/ and /o/. Although this strain on the system did cause some tremendous changes in some Turkic dialects, in others, notably modern Turkish, the system has remained relatively unchanged from Proto-Turkic.

Chagatay is an East Middle Turkic literary language standardized in the latter part of the Fifteenth Century A.D. (Eckmann, 1966). It was heavily influenced by Arabic and Persian, and borrowed freely from both, especially for abstract concepts and poetic language; through these borrowings, a new low front vowel generally transcribed /ä/ was introduced into the system and was ultimately incorporated into it, as is evidenced by its appearance in several grammatical functions, taking over the role of /e/ as a front correspondent to /a/ in vowel harmony. The nine-vowel system of classical Chagatay is shown in Figure 3.

Uzbek, a modern Turkic language spoken by over seven million people in all its dialects, is generally thought to be a modern descendant of Chagatay, and is certainly closely related to it; for the purposes of this paper, I have assumed that the vocalic system of modern Uzbek is ultimately derived from a system identical to that of Classical Chagatay.

Andrée Sjoberg, in her analysis of the Tashkent dialect of Uzbek, cites six vowel phonemes which she transcribes as /i/, /e/, /a/, /ɔ/, /o/ and /u/. In order to trace the collapse of Chagatay's nine-vowel system to the six-vowel system of Uzbek, it is first necessary to examine the allophonic variation of each vowel and determine its norm. This is shown in Figure 4.

The approximate allophonic ranges of Uzbek's six phonemes are shown in Figure 5. The norms of these phonemes (i.e., for each phoneme, that allophone which occurs in the least restricted environment) are shown in Figure 6. A comparison of a large number of cognates (a sample appears in the Appendix)

reveals the correspondences shown in Figure 7.

These correspondences between Chagatay and Uzbek reveal collapses of several front-back vowel pairs that bear explanation, to wit, the collapse of Chagatay /i/ and /ɨ/ to Uzbek /i/, Chagatay /ü/ and /u/ to Uzbek /u/ and Chagatay /ö/ and /o/ to Uzbek /o/. Related to this diminution of the vocalic inventory, there was a related expansion in the consonantal inventory, to wit, the introduction of a distinction (not present in Proto-Turkic) between front and back velars. Both of these tendencies were almost certainly encouraged by Chagatay's extensive contact with and borrowing from Arabic, in which vocalic frontness/backness is nondistinctive, and which does have a front and back series of velars.

Figure 8 shows five stages of allophonic confusion and reorganization proposed for the development of the six-vowel system of Uzbek from the nine-vowel system of Chagatay. In these diagrams, the vertical axis of each matrix shows the four original high vowel phonemes and the horizontal axis shows several pertinent environments for allophonic variation. In the horizontal axis, 'K' represents the regular velar series of stops of Proto-Turkic, 'C' represents palatal consonants, 'N' nasal consonants, and 'Q' a post-velar series borrowed from Arabic.

Stage 1 shows the presumed situation for Proto-East Turkic, before any borrowings. Note that I assume the usual allophonic variation in velars common to most or all languages with one velar series, with fronted allophones before front vowels and backed allophones before back vowels; also note the presumed slight fronting of back vowels before palatal consonants and the presumed laxing and nasalization of all vowels before nasal segments.

Stage 2 shows the relevant inventory for Chagatay, the same as for PET except for the inclusion of the post-velar series borrowed from Arabic.

At Stage 3, there is allophonic confusion in several parts of the system. The backed velar allophones of the regular series of velars are very difficult to distinguish from the post-velar series in the environment of back vowels. Confusion also exists between the fronted allophones of the back vowels in palatal environments, and their front counterparts. Finally, a tendency towards neutralization between front and back vowels in prenasal environment also exists, due to their mutual laxing and nasalization (and possibly also velarization).

At Stage 4, these tendencies have progressed to the point where allophonic merger has taken place in several parts of the system: (1) The backed allophones of the regular velar series have been reanalyzed as allophones of the post-velar series; (2) the fronted allophones of the back vowels in palatal environments have been reanalyzed as allophones of their front counterparts; and (3) the weak distinction between the nasalized allophones of corresponding front and back vowels results in their merger.

At this point, if these were the *only* environments to consider, then the Hypotheses of Economy and Reorganization would come into play; the front/back pairs /i, ɨ/ and /ü, u/ would be in complementary distribution and adjacent in phonological space with no intervening allophones, and therefore ready for reanalysis as allophones (or sets of allophones) of single phonemes.

Before this could happen, however, the confusions and neutralization exemplified in these abbreviated matrices would have to have spread to all other parts of the system. This appears to have been what happened with Uzbek, which exhibits the corresponding system shown in Stage 5, with a complete merger between front and back vowels of corresponding height and roundness.

Note that Uzbek's system, while it retains the velar/post-velar distinction introduced into Chagatay by Arabic, has reduced the vocalic inventory by three, by

merging /ɨ/ with /i/, /ʉ/ with /u/, and (not shown in the matrices) /ɵ/ with /o/; thus, this reanalysis satisfies the Economy of Organization Hypothesis. Interestingly, the distinction between Chagatay /ä/ and /a/ has been maintained in Uzbek. Uzbek /a/ (more correctly, /ä/) while its norm is still at [ä], has spread to include the central vowel [a] in its field, which formerly belonged to Chagatay /a/. The latter has retreated backwards and rounded. This is not unusual; similar backwards migrations of /a/ appear to have happened in Farsi (which, through contact, may have encouraged this trend in Uzbek), and in modern Hungarian.

4. Patterns of Vowel Migration

Labov, Yeager and Steiner (1972) (hereafter, LYS) document in painstaking detail several patterns of vowel migration in a number of dialects of modern American English, using acoustical data obtained from a large number of informants. From their examination of data from a large sample of unrelated languages, LYS describe several frequently observed patterns of vowel migration which they find can be stated in terms of three general principles. These are

(3) *In chain shifts,*
1. Tense (peripheral) vowels rise.
2. Lax vowels fall, especially the lax nuclei of upgliding diphthongs.
3. Back vowels move towards the front.

We will see that my data from Rhode Island dialects (hereafter, freely abbreviated as 'RIese') supports the first of these claims, as it does the third to a lesser extent. At the end of he talk, I will mention one more pattern clearly exhibited by the RIese data that I believe should be added to this list as a general pattern.

If some versions of LYS's first two observations are taken as correct, then we can at least generalize that tense and lax vowels behave differently in terms of their migrations. Not of direct concern to LYS, but relevant here, is what effects this trend can have on phonemic organization. If one of two allophones of a given phoneme is tense and the other lax, any migration will tend to pull the two allophones apart, introducing spreading pressure on the phoneme. If the two allophones move far enough apart, a phonemic change can occur: The phoneme can split; the roving allophone can merge with the allophone of a different phoneme, or can join another phoneme as a new allophone, especially if there is a 'hole' to be filled in that phoneme's repertoire.

5. Rhode Islandese

Determining the vocalic structure of *any* dialect of English is a complex matter, given their large inventories with a preponderance of diphthongs. In this as in earlier studies of dialects spoken in Rhode Island, I have found it advantageous to consider all but a small number of (generally lax) monophthongs as diphthongs, composed of a peak vowel plus a glide (/y/,/w/ or /r/). There are several advantages to this approach, the most important to the current study being that the vocalic inventory can then be displayed in matrix form, making related dialects easier to compare, and making migrations within the system easier to track; for these reasons, it is this approach that I use here.

The representative dialects whose vowel systems I will describe here today I refer to arbitrarily as RI-2 and RI-3. As you might imagine, there is a RI-1, more conservative than the two I will be describing today, but given the limitations of

time. I'll use RI-2 as the starting point today. Of RI-2 and -3, RI-2 is the more conservative of the two, diverging less from Standard American English than RI-3, but still very identifiable as a dialect of Rhode Island and the immediately contiguous parts of Massachusetts. The two dialects are clearly related, and it is reasonable to assume that RI-3 is descended from RI-2.

To show the development of RI-2 through RI-3 and beyond, I have put the vowels and their pertinent allophones in matrix form. The transcription used is loose phonetic, with only as much detail as is relevant to the location and direction of migration of the allophones.

In the matrices, the phonemes (represented by their nuclei) are in the leftmost column, their allophones for various environments in columns to the right. I ignore allophones for unstressed positions. The *lax* allophones occur before obstruents; a nasalized version of the lax allophone occurs before nasal segments. The tense allophones occur before the three glides, /r/, /y/ and /w/. The transcriptions in these columns represent the vowel plus offglide since in some cases, these are inextricable.

On your handout, for reference purposes, I've given correspondences between the two dialects for a few words in (4)

(4) *Some correspondences between SAE, RI-2 and RI-3*

	RI-2	*RI-3*	*Phonemically*
'fear'	[fi^{ə}]	[fi^{ə}]	/fir/
'fair'	[fe$^{\wedge ə}$]	[fɪ^{ə}]	/fer/
'pour'	[p^{h}o$^{\wedge ə}$]	[p^{h}u^{ə}]	/por/ (RI-2), /pur/ (RI-3)
'poor'	[p^{h}u^{ə}]	[p^{h}u^{ə}]	/pur/

5.1 The Model and Analysis.

If you now look at the matrix for RI-2 in Figure 9, which I also refer to as Stage 1 since it is our point of departure today, you will see that already at this stage, as per LYS's hypothesis concerning tense vowels, some of the tense allophones of the mid vowels /e/ and /o/ are noticeably raised. In addition, under the influence of the labiodental articulation of /r/ for these speakers, rounded versions of the tense pre-rhotic allophone of the central vowel represented by the numeral '3' on the handout, become the norm. I have used '3' rather than schwa here to emphasize that this vowel is somewhat higher and tenser than the corresponding vowel in most dialects.

The trend of the pre-rhotic allophones of the mid vowels /e/ and /o/ to rise continues, but proceeds at a faster rate for /o/ than for /e/; the allophone of /o/ before y also continues to rise. Another trend that continues is the increasing rounding of the pre-rhotic allophone of /3/; a fourth trend is the appearance of a free alternation between rounded and unrounded pronunciations of the allophone of /o/ occurring before /w/. The presence of these trends is representative of Stage 2, Figure 10.

The status of phonemic /o/ is clearly threatened at this stage. The pronunciations of /ur/ and /or/ are so close that confusion is very likely to occur, and merger is possible if minimal pairs are relatively few. If these two allophones do merge, the stage is set for a reanalysis.

This is, in fact what has happened for some speakers. Thus, while speakers at Stage 2 minimally distinguish 'pour' /por/ [p^{h}U^{ə}] from 'poor' /pur/ [p^{h}u^{ə}], they are both /pur/ [p^{h}u^{ə}] for speakers at Stage 3. A merger between /ur/

and /or/, the continued rising of /e/ before /r/ and the complete fronting of the central vowel before /r/ results in the matrix shown as Stage 3, Figure 11.

Note that in this matrix, the only two remaining allophones of /o/ are adjacent to holes in the matrix. I've shown this with arrows on your handout. The completely raised allophone of /o/ before /y/ overlaps into the field of /u/, and the allophone(s) of /o/ occurring before /w/ overlap the field for /3/. The conditions for reorganization are met, and the system collapses into a more economical system with only five distinct phonemes, shown as Stage 4, which is representative of RI-3, the more innovative of the two attested dialects (see Figure 12). For speakers of this dialect, the words 'poor', 'pore' and 'paw' are all phonemically /pur/, phonetically [p^{h}u^{ə}]; 'bird' is /b3rd/, pronounced [bö^{ə}d].

The most obvious candidate for a Martinetian 'germ of instability' in this dialect is the extreme proximity of the pre-rhotic allophones of /i/ and /e/. For some speakers, there may be some evidence of the early stages of confusion that could lead to the merger of these two allophones, probably, given the nature of their very raised pronunciations, in favor of /i(r)/. For example, there are speakers who, while they keep the vowel peaks of the high-frequency words 'here' and 'there' distinct, make no distinction between 'fear' and fair', both /fir/ [fi^{ə}]. If this kind of confusion were to spread to an increasing number of pairs via lexical diffusion, it could eventually affect enough of the lexicon to permit a merger.

5.2 Predictions

From this point on, I use the model, the universal tendencies observed by LYS, and the hypotheses of economy and reorganization to speculate as to what further innovations are likely in RIese. My speculations begin with the assumption that the aforementioned trend in the most innovative of the established dialects continues, leading to a merger of /ir/ and /er/, and the loss of the pre-rhotic allophone of /e/. The vowel matrix for this stage would be as shown in Stage 5, Figure 13.

As can been seen from the matrix, the cross-allophonic opposition between /e/ and /3/ continues only in the lax series. In addition, there are no phonemes with allophones intervening between the remaining allophones of /e/ and the widely scattered allophones of /3/; they are adjacent.

Merger between /e/ and /3/ is blocked, then, only by virtue of the existence of lax allophones for both phonemes. There seems little chance of confusion between the lax allophones of /e/ and /3/, given their divergent pronunciation. Much more likely is confusion between the lax allophones of /u/ and /3/. As it happens, the degree of rounding for the lax allophone of /u/ is not great; and, while there are a number high-frequency minimal pairs contrasting these allophones (e.g., 'buck' vs. 'book', 'luck' vs. 'look' and others), the absolute number of minimal pairs is not very high. It is not implausible, then, that conditions could ultimately arise for confusion to grow between the lax allophones of /u/ and /3/.

Let us assume, then, that less rounded versions of the lax allophone of /u/ become more and more frequent, eventually predominating, and that confusion between the lax allophones of /u/ and /3/ results. The question that now arises is to what phoneme will the resulting merged allophone be assigned? Although it would *a priori* seem to be more appropriate to assign the allophone to /3/, given its lack of rounding, the status of /3/ as a distinct phoneme from /e/ is under question, since the functional load of their opposition is weak. Certainly there is no problem assigning the allophone to /u/, since it is adjacent and there are no intervening allophones. Given the questionable status of /3/ and the absence of any compelling

argument against assigning the merged lax allophone to /u/, let us assume that this is what happens. With this merger and assignment, the system appears as is shown in Stage 6, Figure 14.

With the loss of the lax allophone of /3/ to /u/, the last impediment to the merger of /e/ and /3/ is removed. Since the two phonemes are adjacent and do not contrast in any environment, the conditions for their merger are met. With this reorganization, the number of vowel phonemes is reduced to four. Since the rounded allophones of the new merged phoneme occur in environments that condition rounding and the lax phoneme is front mid unrounded, it is represented in the matrix by /e/. Figure 15 shows Stage 7, the matrix for this last speculative configuration.

I end my speculations here. With this collapse, the system seems to have reached a modicum of stability, with no dangerously close allophones and no holes in the matrix. While all migrations and mergers thus far predicted have been based on observed trends, any further speculation would amount to little more than guesswork. A tentative universal trend that this data would seem to support is (5):

(5) Tense allophones will tend to migrate more rapidly than lax allophones.

While it's possible that this trend is an artifact of these dialects, I suspect further research may bear it out.

6. Conclusion.

My feeling is that the space theoretical model and the hypotheses of Economy and Reorganization I've used here seem reasonable, and some version or versions of them could be of some use as practical guides in tracing the courses of already established sound change. Whether collectively they have any predictive power, of course, remains to be seen.

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Diagrams

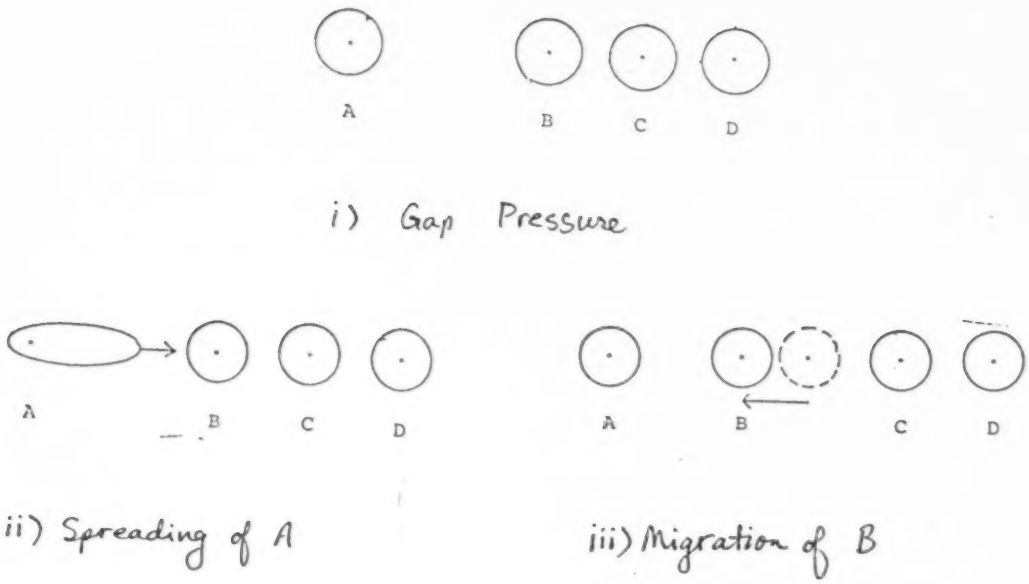


Figure 1: Some examples of terms.

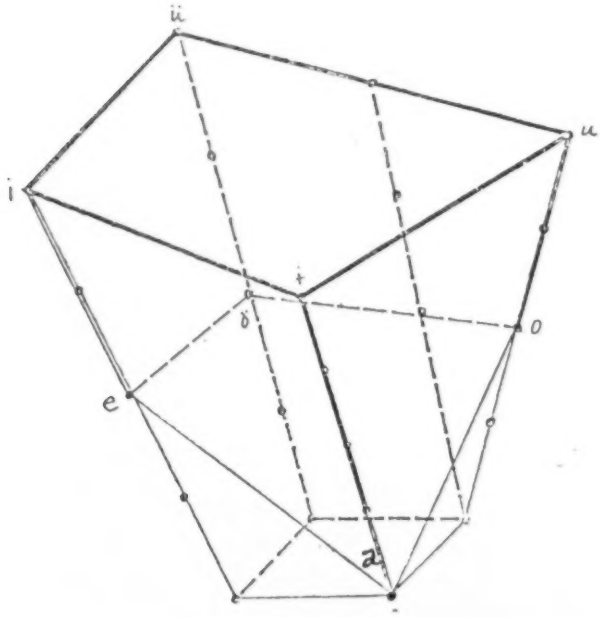


Figure 2: Proto-Turkic Vocalic Inventory

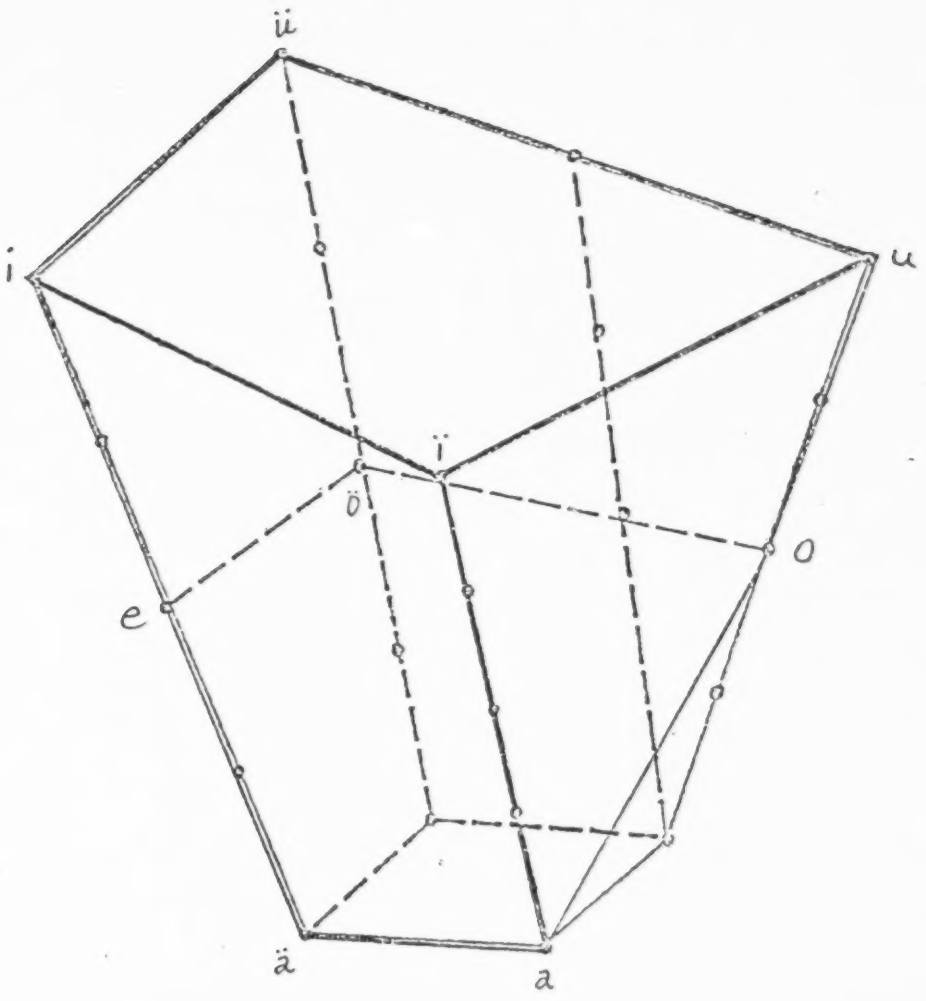


Figure 3: Classical Chagatay

/i/: [ɜ] , occurring finally
[ɤ] , occurring in environment of /q, x, ǧ/
[ɪ] , occurring in environment of /m, n, r/
[i] , occurring elsewhere

/e/: [ɛ] , occurring after /y/ in non-initial syllables
[é] , occurring interconsonantally in initial syllable
[e] , occurring elsewhere

/a/: [a] , occurring in environment of /q, x, ǧ/
[ä] , occurring elsewhere

/ɔ/: [ɔ] , occurring in environment of /q, x, ǧ/
[å] , occurring elsewhere

/o/: [ö] , (rare), occurring in environment of /k, g, y/, sometimes /t, š, č, ǰ/
[o] , occurring in environment of /q, x, ǧ/
[ó] , occurring elsewhere

/u/: [ü] , occurring in environment of /k, g, y/, sometimes /t, š, č, ǰ/
[u] , occurring in environment of /q, x, ǧ/
[ú] , occurring elsewhere

Figure 4: Allophonic variation in Uzbek

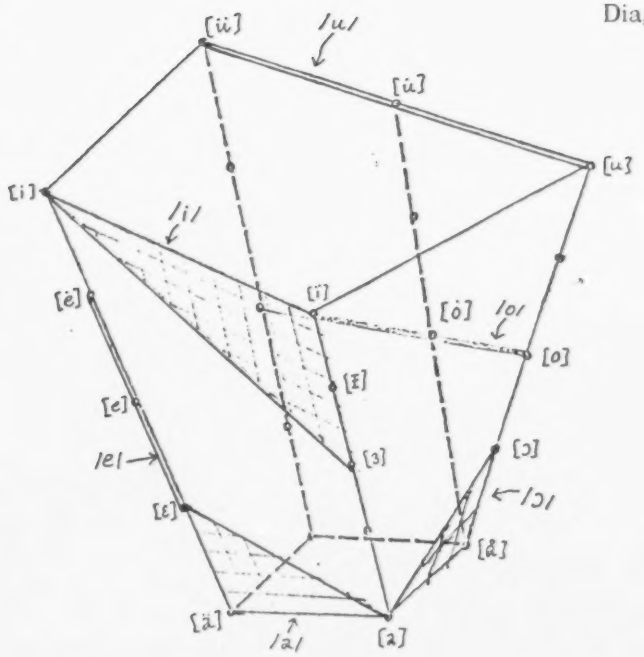


Figure 5: Ranges of Uzbek vowel phonemes

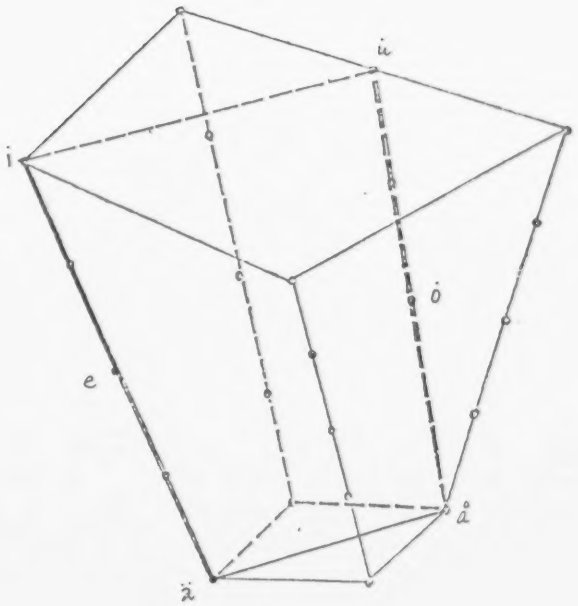


Figure 6: Norms of Uzbek vowel phonemes

Chagatay		Uzbek
/i/	>	/i/
/ɨ/	>	/i/
/e/	>	/e/
/ă/	>	/a/
/ŭ/	>	/u/
/u/	>	/u/
/ŏ/	>	/o/
/o/	>	/o/
/a/	>	/ɔ/

Figure 7: Chagatay-Uzbek correspondences

Diagrams

	K-	C-	-N
i	ki	ci	Im
ɨ	kɨ	cɨ	Im
ü	kü	cü	Üm
u	ku	cu	Um

Stage 1: Proto-Eastern Turkic

	K-	Q-	C-	-N
i	ki	–	ci	Im
ɨ	kɨ	qï	cɨ	Im
ü	kü	–	cü	Üm
u	ku	qu	cu	Um

Stage 2: Chagatay

	K-	Q-	C-	-N
i	ki	–	ci	Im
ɨ	kɨ	qï	cɨ	Im
ü	kü	–	cü	Üm
u	ku	qu	cu	Um

Stage 3: Allophonic confusion

	K-	Q-	C-	-N
i	ki	–	ci	–
ɨ	–	qï	–	Im
ü	kü	–	cü	–
u	–	qu	–	Um

Stage 4: Allophonic merger

	K-	Q-	C-	-N
i	ki	qɨ	ci	Im
u	kü	qu	cü	Üm

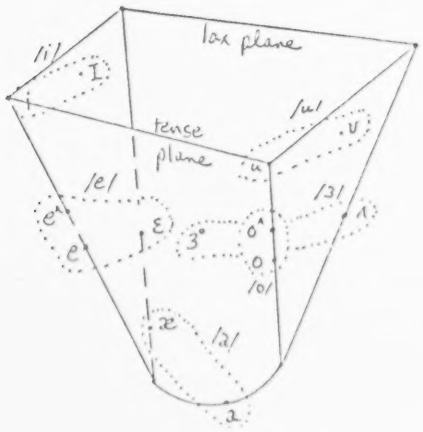
Stage 5: Reorganization: The Uzbek System

Figure 8: From Proto-Eastern Turkic to Uzbek

Diagrams

Stage 1 = RI-2

	Lax	_r	_y	_w
i	I	i$^{\partial}$	i:	i$_{u:}$
e	ɛ	e$^{\wedge\partial}$	e^{i}	–
a	æ	a:	a^{i}	a^{u}
3	ʌ	3$^{\wedge\partial}$	–	–
o	–	o$^{\wedge\partial}$	o$^{\wedge i}$	o^{u}
u	U	u$^{\partial}$	–	u:



Model for Stage 1 (= RI-2)

Figure 9

Stage 2

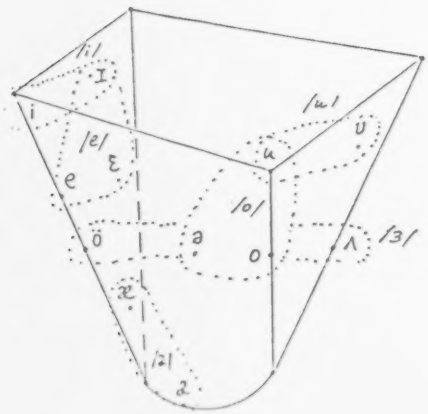
	Lax	_r	_y	_w
i	I	i$^{\partial}$	i:	i$_{u:}$
e	ɛ	e$^{\wedge\partial}$	e^{i}	–
a	æ	a:	a^{i}	a^{u}
3	ʌ	ɔ$^{\partial}$	–	–
o	–	U$^{\partial}$	U$^{\supset i}$	o^{u}/ʌ^{u}
u	U	u$^{\partial}$	–	u:

Figure 10

Diagrams

Stage 3

.	Lax	_r	_y	_w
i	I	iə	i:	iu:
e	ɛ	Iə	ei	–
a	æ	a:	ai	au
3	ʌ	ɵ ə	–	–
o	–	–	u ɔ̇i	ou ə u
u	U	uə	–	u:

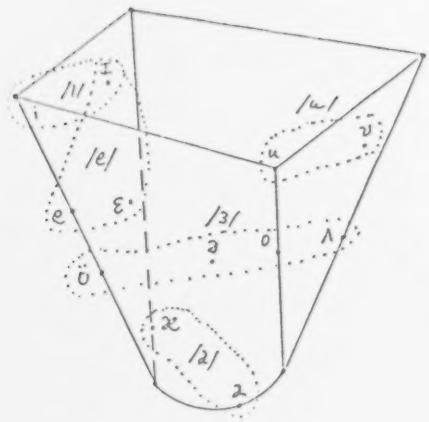


Model for Stage 3

Figure 11

Stage 4 = RI-3

.	Lax	_r	_y	_w
i	I	iə	i:	iu:
e	ɛ	Iə	ei	–
a	æ	a:	ai	au
3	ʌ	ɵ ə	–	ou ə u
u	U	uə	u ɔ̇i	u:

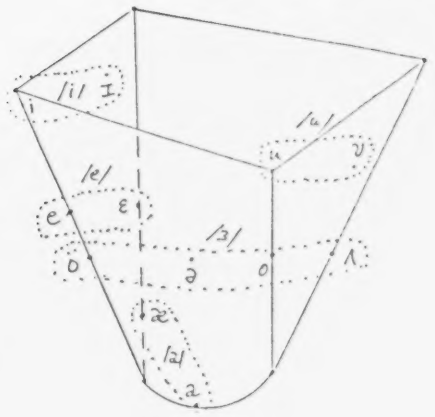


Model for Stage 4 (= RI-3)

Figure 12

Stage 5

	Lax	_r	_y	_w
i	I	$_{i}$ə	i:	^{i}u:
e	ɛ	–	e^{i}	–
a	æ	a:	a^{i}	a^{u}
3	ʌ	ö ə	–	o^{u}/ə ^{u}
u	U	$u^{ə}$	u ɔ^{i}	u:



Model for Stage 5, showing proximity of /e/ and /3/.

Figure 13

Stage 6

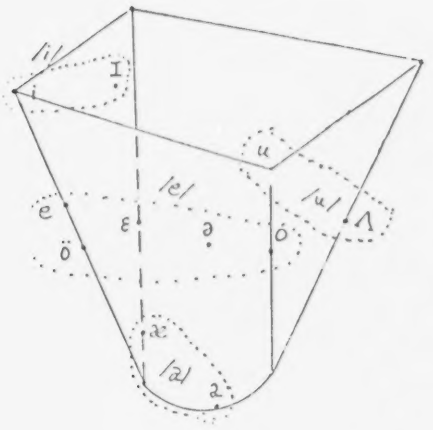
	Lax	_r	_y	_w
i	I	$_{i}$ə	i:	^{i}u:
e	ɛ	–	e^{i}	–
a	æ	a:	a^{i}	a^{u}
3	–	ö ə	–	o^{u}/ə ^{u}
u	ʌ	$u^{ə}$	u ɔ^{i}	u:

Figure 14

Diagrams

Stage 7

	Lax	_r	_y	_w
i	ɪ	ɪ^{ə}	i:	i$_{u:}$
e	ɛ	ö^{ə}	e^{i}	o^{u}/ə^{u}
a	æ	a:	a^{i}	a^{u}
u	ʌ	u^{ə}	u ɔi	u:



Model for Stage 7, with four phonemic vowels.

Figure 15

Appendix

Chagatay	English	Uzbek
/i/		/i/
iš	work	iš
bil-	to know	bil-
bir	one, a	bir
biz	we	biz
kim	who?	kim
kir-	to enter	kir-
til	tongue, language	til
ikki	two	ikki
istä-	to want	istä-
bilä	with	bila(n)
kisi	person	kisi
tilä-	to wish; beg	tilä
ič	inside	ič
/ɨ/		/i/
čɨq-	to go out	čiq-
qɨl-	to do, make	qil-
qɨr-	to break	qirq-
qɨs	winter	qiš
qɨz	girl	qiz
yɨğ-	to pile up	yiğ-
yɨl	year	yil
ɨsɨq	hot, warm	isi
qɨzɨl	red	qizil

Appendix (cont.)

Chagatay	English	Uzbek
/ä/		/a/
ägär (P)	if	agar
äylä-(P)	to do, make	ayla-
bälki (P)	but, however	balki
bärg (P)	leaf	barg
häm (P)	also	ham
här (P)	each	har
käm (P)	few	kam
šäkär (P)	sugar	šakar
vä (A)	and	va
/ü/		/u/
üč	three	uč
üst	top	ust
üz-	to cut off	uz-
kün	day; sun	kun
sür-	to drive away	sur-
türk	Turk, Turkish	turk
tüš-	to descend	tuš-
yüz	face	yuz
yüz	one hundred	yuz
bütün	whole, entire	butun
üčün	because of	učun
üzrä	over	uzra
üzüm	grape	uzum
yürak	heart	yurak
yürü-	to walk, march	yur-
/u/		/u/
uluġ	big	uluğ
unut-	to forget	unut-
ur-	to hit	ur-
yu-	to wash	yuw-
bu	this	bu
buz-	to ruin	buz-
qum	sand	qum
quš	bird	quš
tur-	to stand, stay	tur-
tut-	to hold	tut-
/e/		
el	people	el
e(r)-	to be	e-
ber-	to give	ber-
beš	five	beš
de-	say	de-
kel-	come	kel-
ket-	to go away	ket-
men	I	men
sen	thou	sen
sev-	to love	sev-
teg-	to touch	teg-
ter-	to gather	ter-
ye-	to eat	ye-
yer	earth, place	yer
yet-	to reach, attain	yet-

Appendix (cont.)

Chaqatay	English	Uzbek
/ŏ/		/o/
ŏl-	to die	ol-
ŏt-	to go by	ot-
ŏz	self	oz
ŏzbek	Uzbek	ozbek
köküs	breast	koks
köp	much, many	kop
kör-	to see	kor-
kötär-	to raise	kotar-
köz	eye	koz
sŏz	word	soz
tŏk-	to pour	tok-
tŏrt	four	tort
/o/		/o/
on	ten	on
oq	arrow	oq
oqu-	to read	oqi-
ot	fire	ot
bol-	to be, become	bol-
qol	arm, wing	qol
qorq-	to fear	qorq-
qoy-	to put	qoy-
yol	way, road	yol
yoq	nonexistent	yoq
sora-	to ask	sor-
tol-	to be filled	tol-
/a/		/ɔ/
ač-	to open	ɔč-
al-	to take, buy	ɔl-
ag-	to flow	ɔq-
aš-	to hang	ɔš-
as-	to pass beyond	ɔs-
at	horse	ɔt
at-	to throw	ɔt-
av	game, hunting	ɔv
ay	moon, month	ɔy
baq-	to look at	bɔq-
bar	there is, are	bɔr
bar-	to go away	bɔr-
bas-	to press, tread on	bɔs-
baš	head	bɔš
bay	rich	bɔy
čap-	to gallop	čɔp-
qač-	to flee	qɔč-
qal-	to remain	qɔl-
qaš	eyebrow	qɔš
san	number	sɔn
sat-	to sell	sɔt-
taġ	mountain	tɔğ
tap-	to find	tɔp-
tart-	to draw, pull	tɔrt-
taš	stone	tɔš
yag-	to rain, fall	yɔg-
yan	side	yɔn
yan-	to burn (intr.)	yɔn-
yaq-	to burn (trans.)	yɔq-
yat-	to lie, go to bed	yɔt-
yaz	summer	yɔz
yaz-	to write	yɔz-